INDUSTRIAL LIGHTING SURVEY OF THE CITY OF CHICAGO

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1921

INDUSTRIAL LIGHTING SURVEY OF THE CITY OF CHICAGO

A THESIS

PRESENTED BY

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TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

JUNE 2, 1921

APPROVED

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P R E F A C E .

With the wider application of artificial lighting, due to its appreciated worth, more efficient lighting installations are in demand. At present the tendency is for more foot-candles of illumination. These conditions require refinements, which were formerly considered unimportant; the selection and spacing of lighting units, coefficient of utilization, depreciation of the system and other factors which influence the efficiency of the installation must be handled with greater consideration of the requirements of the individual system. To take the essential factors into account has appeared so complicated to most designers, that general

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systems were used, which, while satisfactory in some instances, were inadequate in others.

In the discussion of this thesis, methods of design are outlined, which take into account the technical requirements which come up in every installation.

STORE LIGHTING.

To generalize, we may say that store lighting should be of high enough intensity for convenience to the customer and of such design that it is economical to operate. In order that the stores would be representative of conditions in most any city, stores of like character and local conditions were considered. This necessitated going outside of the loop, because the loop stores are considered higher-grade establishments and not representative of general conditions. Business sections on the North, West and South sides of like conditions were decided upon. An equal percentage of each grade in each locality was visited.

It was necessary to visit over a thousand establishments before satisfactory data could be obtained.

The stores visited come under the following classification:

Candies	Restaurants
Dry Goods	Groceries
Bakeries	Furniture
Tailors	Drugs
Meat Markets	Cigars

This survey shows that a very small percentage, namely 28%, have an intensity greater than 5 foot-candles and only 6% have intensities ranging from 8 to 12 foot-candles. These figures show that only 6% of the stores in the country have proper lighting at the present time.

The survey also shows that 59% of the installations are direct lighting and even 23% were using bare lamps. 41% of the stores are using Mazda "C" lamps, while 14% are still using Mazda "B" lamps. This shows that the store owners are awake to the efficiency of the system, as far as bulbs are concerned.

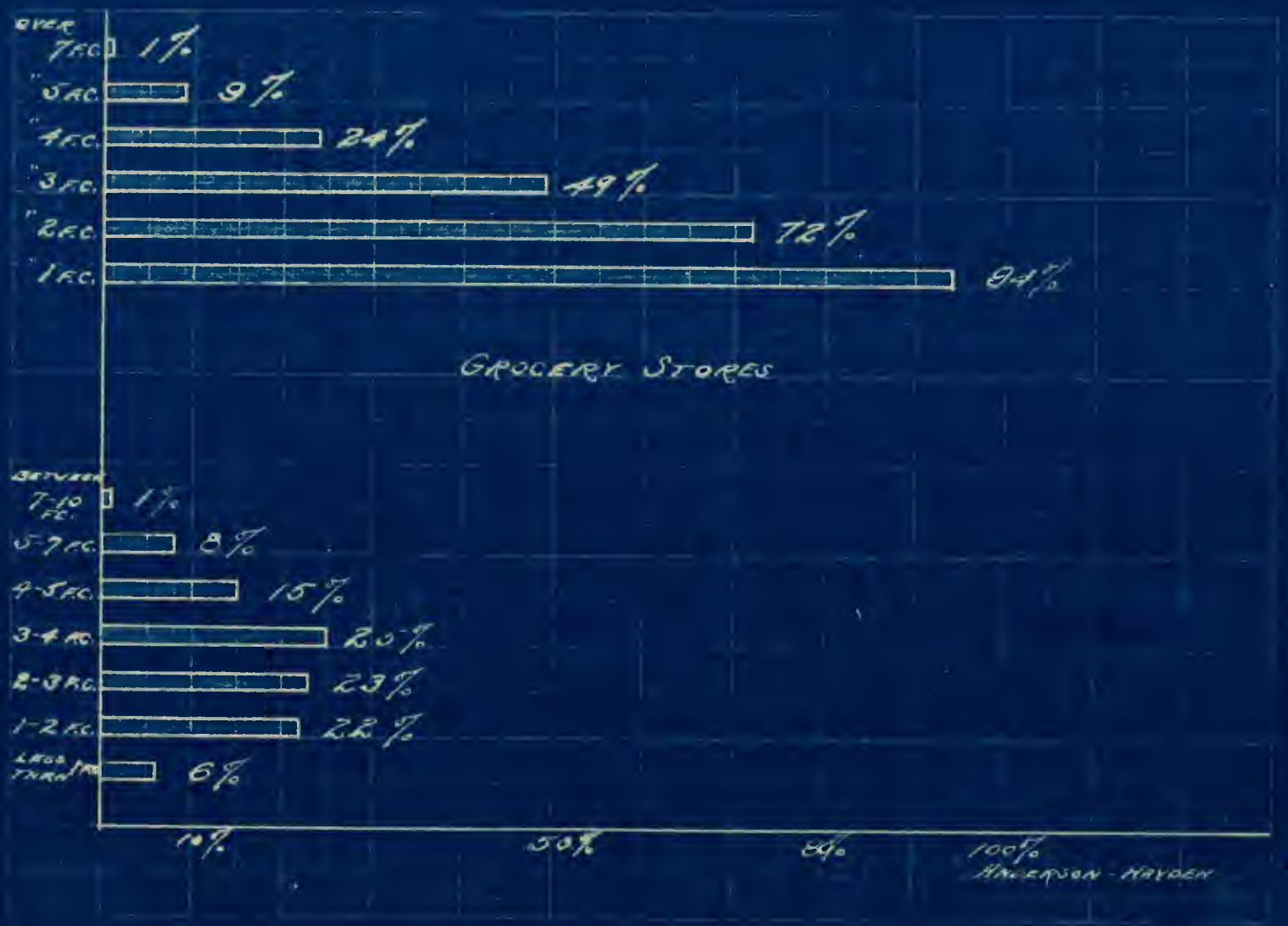
The maintenance of the systems was very poor. Equipment, such as the glassware, deteriorates very gradually by the accumulation of dust, and the loss of efficiency is not quickly noticeable. The loss is, of course, due to dust and grease, depends upon the local conditions and the frequency of cleaning. Average owners considered their systems in first class condition, even when they had not

Table #4.

Class of Business	Type of Fixtures				Type of Lamps		
	%Direct	%S.I.	%Bare	%Diff.	%"C"	%"B & C"	%"B"
Bakeries	63	14	20	45	57	33	11
Candy	47	14	31	8	40	53	7
Cigar	76	7	11	6	55	35	10
Drug	63	16	14	7	32	50	18
Dry Goods	64	12	12	12	50	46	4
Groceries	86	2	7	5	48	34	18
Meat Market	79	5	10	6	45	40	15
Restuarant	28	10	53	9	29	61	10
Tailors	77	4	6	13	37	38	25
Furniture	76	4	10	10	45	32	23

Table #5.

Class of Business	Floor Area			Watts Per Sq. Ft.			Foot Candles		
	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.
Bakeries	196	2750	722	.2	3.8	1.07	.5	7	3.4
Candy	360	2000	849	.2	7.7	1.4	.5	12	4.6
Cigar	100	1600	512	.4	7.8	2.25	.5	16	6.1
Drug	200	3000	908	.3	4.6	1.5	.6	10	4.5
Dry Goods	300	32000	2023	.2	4.7	1.0	1.0	10	4.3
Gro'ies	300	1400	798	.2	3.0	1.1	.5	8	3.9
Meat Market	308	1800	708	.3	3.6	1.3	.6	10	4.0
Rest'nt	420	1600	890	.3	4.8	1.5	.5	10	3.9
Fur'ure	480	21750	4566	.2	5.0	1.69	.6	9	4.1


OVER 7 AC. 1%
" 5 AC. 9%
" 4 AC. 24%
" 3 AC. 49%
" 2 AC. 72%
" 1 AC. 94%
GROCERY STORES
BETWEEN 7-10 AC. 1%
5-7 AC. 8%
4-5 AC. 15%
3-4 AC. 20%
2-3 AC. 23%
1-2 AC. 22%
LESS THAN 1 AC. 6%
10%
50%
100%
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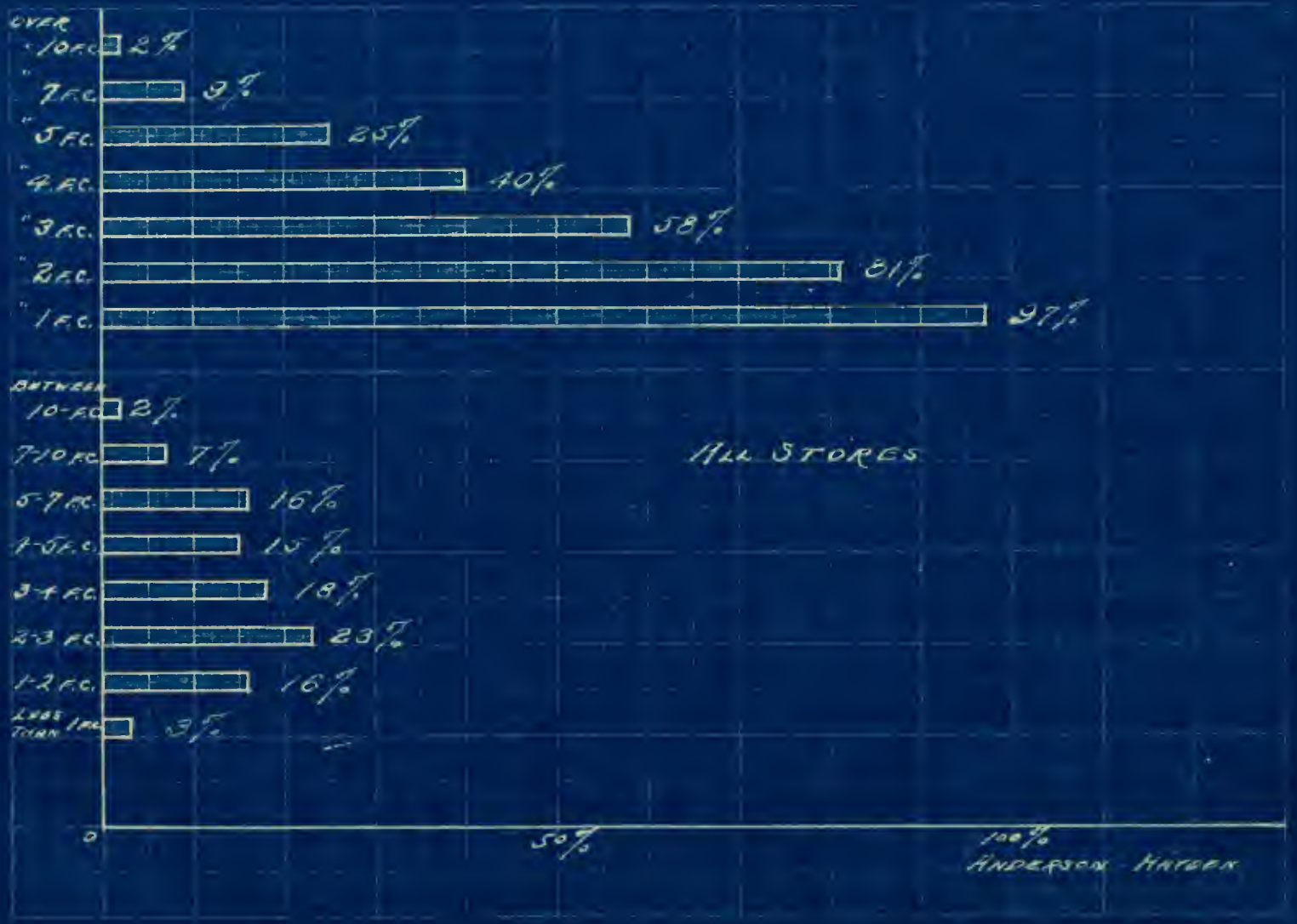
OVER 10 F.C. 2%
" 7 F.C. 9%
" 5 F.C. 25%
" 4 F.C. 40%
" 3 F.C. 58%
" 2 F.C. 81%
" 1 F.C. 97%
BETWEEN 10-7 F.C. 2%
7-10 F.C. 7%
5-7 F.C. 16%
4-5 F.C. 12%
3-4 F.C. 18%
2-3 F.C. 23%
1-2 F.C. 16%
LESS THAN 1 FC 3%
ALL STORES
0
50%
100%
ANDERSON HATCHER

been cleaned for some time. Tests made before and after cleaning showed that a loss of from 35 to 40% was due to the accumulation of dust and grease.

We have seen how these stores are lighted and systems maintained and will now see how this practice compares with the accepted standards. Efficiency is the first requirement of a lighting system for the usual small store. The fixtures may be of a very simple design, but the intensity must be high to provide convenience for customers and attractive advertising. Consequently, direct lighting, with open reflectors of the prismatic or dense-opal type, or with a good type of semi-enclosing unit, is, as a rule, most applicable, although often the

installation of an inexpensive semi-indirect or enclosing unit is preferable.

In locations where open reflectors would cause annoying glare, semi-enclosing units possess an advantage over open reflectors in that they diffuse the light from the filament over a comparatively large area; hence they may be used with any size of lamps. They possess an advantage over opal enclosing units in that they distribute light in much the same way as a dense opal open reflector and are, therefore, less dependent for their efficiency upon the finish of the walls and ceiling.

A mistake which is common in small store lighting is the installation of a single row of direct lighting reflectors along the center of the store, where at

least two rows of smaller units should be used to prevent the customer's shadow from interfering with his examination of the wares, and to illuminate the shelving or high cases along the side walls. A single row of semi-indirect or enclosing units is, however, usually satisfactory. In jewelry stores an exception may be made to the use of the bowl frosted lamps with open reflectors, where brilliant reflections in gems and cut glass may be desirable. The units should, however, be placed well above the usual line of vision to avoid glare.

A lighting installation serves, in general, two purposes:

First: It permits the merchandise to be examined with comfort.

Second: It advertises the store.

As good illumination is an advertising asset of relatively low expense, intensities higher than those needed for comfort are demanded. Required intensities are, of course, dependent upon the nature of the merchandise, dark goods requieing higher values of intensity. In the back of this report a table is submitted which gives the intensities recommended by the National Electric Light Association.

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FACTORY LIGHTING.

Factory lighting presents one of the most important and difficult problems in lighting engineering. It is only recently that, through extensive experimentation, some manufacturers have come to realize the full value of the effect of light intensity on production.

It was found, in the tests made, that, in general, the lighting in factories was insufficient. Each worker was without light of high enough intensity upon his work, much floor space was found not being used to the greatest extent, because of poor distribution, and many shadows were in evidence, which reduce production.

To give each and every factory the best and most efficient lighting system,

the requirements for good illumination must be thoroughly understood and care must be taken in applying these requirements to each type of factory.

There are four requirements which must be met in the design of a satisfactory lighting installation. They are:

First: Sufficient light of the proper quality on the work.

Second: A moderate intensity of light over the surrounding area and on the walls.

Third: Absence of glare.

Fourth: A system which is simple, reliable, easy of maintenance and low in operating cost.

The most important requirement for satisfactory illumination is that the quantity of light on the work be sufficient. It is becoming a practice now

to better the lighting facilities along with other improvements in factories for the purpose of decreasing the unit cost of production to a minimum. However, from an economic standpoint, it is very difficult, if not impossible, to determine the proper intensity of light for a given class of work. This intensity depends upon the cost of producing light, the number and wages of the employees and the value of their output, as well as upon the nature and fineness of the work and the possible reduction in spoilage. Because of the great difficulty of determining the value of each of these quantities, estimates of the intensity of light required for a specific class of work

have usually been based on other than economic considerations.

It is unnecessary to state that the intensity at any place in a factory should never fall so low that accidents may be caused thereby. From a standpoint of safety to employees alone, .25 foot-candles may be used as the lowest value permissible in a factory.

The upper limit has been estimated to be between 50 - 100 foot-candles. Illumination of such very high intensity is sometimes required for operations involving fine detail, rapidly moving machinery and black surfaces, such, for example, as are common in the shoe industry. The necesary volume of incident light will depend upon the coefficient of reflection of the object il-

luminated, but even for fine work on very dark goods, intensities of the order of those stated above are considered satisfactory. Such intense illumination is ordinarily required over only a limited area and so can best be supplied by placing a small lamp with a reflector close to the work.

Although .25 - 100 foot-candles may be considered the range of light intensity for the various types of factories, yet most of the present installations will fall between 1 and 6 foot-candles. There are numerous tables published that designate the proper intensity of illumination for various classes of work, but this intensity is dependent so largely upon the nature and distribution of the lighting units and upon local conditions

and the work to be done, that such tables should be used with caution. Also, as has been stated before, such estimates are, at best, based merely on what is now considered good practice in plants where illumination tests have been conducted. As a matter of fact, the cost of adequate illumination for an industrial plant is so low in comparison with the value of the output dependent upon it, that in many cases intensities considerably higher than those now supplied will be found profitable.

It is very essential that there be sufficient units supplying light from many directions to give satisfactory lighting from a general overhead system. For, if a unit should burn out, or the light from a lamp should be intercepted

either by the operator's body or parts of machinery, the resulting decrease in intensity must not be serious. In an installation of few large units, shadows are likely to be pronounced, and then, too, there is a very decided decrease in illumination when one lamp is extinguished, and because of this, the time of many workmen may be lost. A smaller unit will affect a smaller area, and this area to a lesser degree. These are the requirements to get good diffusion.

Uniformity of illumination is also a result of having a larger number of units over an eara. It is impracticable even to approach uniformity of illumination where the distance between units is greater than twice their height above the work; one and one-half times this height is a more satis-

factory ratio. For a given mounting height, the allowable spacing of units is constant and independent of their candle-power. It can be seen from the reasons given abovem that an illumination consisting of a large number of units of low intensity will usually prove more satisfactory, and in the end more economical, than one of few units of high intensity.

Another requirement of importance is steadiness of the light source. The importance of a steady light can be brought out by an illustration. If you leave a dark room and go into bright sunshine, the sensation is unpleasant to the eye; if you use a light that flickers, you get this same unpleasant sensation, but many more times per minute. The eye

tries to adjust itself to suit the light, so if the light flickers, it keeps the iris of the eye sea-sawing back and forth and the muscle that governs it gets tired and reacts on the nerve to cause pain.

In some manufacturing processes color distinctions are an aid to vision, and even a necessity. The appearance of the sun on a smoky or foggy day illustrates the fact that light of the longer wave lengths - that is, toward the red end of the spectrum - is particularly effective in penetrating smoke and steam. The spectral character of the light is also important, because of its effect upon the operatives. The mellow light of the yellow and red rays is stimulating; it promotes activity and is conducive to a cheerful state of mind.

In any particular factory lighting system, the adjacent objects and shafts and belting, as well as the walls and ceiling, should be provided with a certain amount of light. In some shops the intensity is so low, except at a few points, that it is hard to see one's way about the place. Lighting of this kind is not only insufficient from a standpoint of safety, but also strains the eye. If just the work is highly illuminated, and the rest of the shop is in comparative darkness, the uneven intensity encountered by the eye causes the same tiring effect as that of a flickering light source.

From the psychological standpoint, bright walls and ceiling lend an air of cheerfulness and wide-awakeness to a room,

which is wanting where the work only is illuminated. If, as in a cotton or a paper mill, the materials are of such a color that they will reflect a large proportion of the light incident upon them, the resulting illumination received on the walls and ceiling will be sufficient to obviate any appearance of gloom. If, on the other hand, the working surface is too dark to reflect much light, it may be taken care of by placing a few units so they will illuminate the walls and ceiling. Units of this kind would have to be placed close to the ceiling and enclosed in diffusing envelopes. To keep the walls and ceilings of a plant well white-washed will add materially to the appearance of the shop and also increase the efficiency of the lighting installation.

Glare may be said to be "light out of place." Any surface that is in the field of vision and is brighter than an object to be viewed, will reduce the ability of the eye to distinguish the object. Glare is not necessarily produced by a light source, but any highly polished object, or, in fact, any brightly illuminated surface that falls in the line of vision.

Through investigation, it was found that the extent the vision was impaired by glare depends, primarily, upon the total quantity of light received by the eye directly from the source, rather than upon the brilliancy; therefore, the distance between the eye and the source is of importance. If the candle-power per unit area is low, the effect of glare usually

disappears very soon after the cause is removed. If, however, the source is one of high candle-power per unit area, such as the filament of a Mazda lamp, or the crater of an arc, it may not only decrease the ability to see during its presence within the field of vision, but will also tire or permanently injure the eye. The distance between the eye and the light source, and the brightness of the background against which the source is viewed, determines, to a great extent, the injury caused by the latter effect.

To avoid the objectionable aspects of glare, the lighting system should be designed in correspondence with the following requirements:

First: No source of light of high intensity should be located so that it can

be readily seen , except at a considerable distance. In cases where it is impossible to screen the source entirely, the presence of a brightly lighted background, such as the surface of a reflector, will considerably diminish the harmful effect.

Second: No considerable amount of light, even from a well diffused source, should be allowed to enter the eye directly when it is focused on the work; this usually requires that no light source, unless remote, be visible when the head is inclined toward the working surface.

Third: It is desirable that the area within the field of vision be uniformly illuminated; at least, the brightness of any portion of this area should not be materially greater than that of the object under observation.

Fourth: Specular reflection should be guarded against, so far as possible. Where the position of objects worked upon is fixed, and the greater portion of the work is in one plane, lamps can be so placed as to avoid specular reflection in the direction of the eye. In the majority of operations in industrial plants, however, such conditions do not exist and one should direct his efforts toward producing conditions which will allow the operator readily to shift his position in such a manner that direct reflection cannot reach the eye.

In order to get some first-hand information on a recent installation, an appointment was made to test the Kilbourne Ave. Shops of Alfred Decker Cohn Co. The installation at this plant consists

-of a general system, aided by local fixtures. The layout is as given in blueprint, which is found in the back of this report. All overhead fixtures are steel enameled reflectors, fitted with frosted Mazda "C" lamps. As an outgrowth of old systems, workers demanded local fixtures for close work, such as on sewing machines, etc. These fixtures are not a necessity, from the standpoint of illumination, but are required because of labor contracts to which the company is a party.

The units were spaced in such a way as to prevent shadows, whihh would be objectionable in this kind of work. At the same time, a uniform intensity was obtained. Tests made in these shops proved this, and showed an average intensity of over eleven foot-candles.

STEPS IN THE DESIGN OF A LIGHTING SYSTEM.

The four steps to be carried out in the design of a general lighting system for a room are:

1. Decide the foot-candle illumination required.
2. Select the type of lighting unit best adapted to the location.
3. Determine the location of outlets, the mounting height and number of lighting units required.
4. Ascertain the size of Mazda lamp which will provide the foot-candles desired.

1. FOOT-CANDLE ILLUMINATION.

Table 1 lists the foot-candle values, corresponding to present standards, for different classes of industrial operations, offices, stores, factories, etc. The desirable illumination varies rather widely, depending on the conditions in any particular

installation, such as the accuracy of the operation and fineness of detail to be observed, the color of goods worked on or handled and, in case of stores, the advertising value resulting from the attractiveness of a well-lighted interior. The foot-candle values recommended in the table are the mimimum to be adhered to, if fully satisfactory lighting is to be assured. Under particular conditions, considerably higher illumination is often desirable.

2. TYPE OF LIGHTING UNIT.

The selection of the type of lighting unit depends not only upon the requirements of the work, but in some cases upon the construction of the room and the color of the ceilings and walls. For example, semi and totally indirect lighting is unsuited to rooms with very dark ceilings. It is important to specify the type of lamp to be used, since, for example, bowl

enameled lamps used in open reflectors, such as R L M standard domes, form a much superior lighting unit, from the standpoint of glare, reflected glare, and shadows, than clear lamp units of the same type. In general, clear Mazda "C" lamps should not be used in open reflectors where the mounting height is less than 20 feet.

Other factors may enter into the choice of the lighting unit in certain instances. For example, in stores, offices and other public installations, decorative effect is often an important item.

3. LOCATION OF OUTLETS, MOUNTING. HEIGHT, AND NUMBER OF LIGHTING UNITS.

Make a diagram to scale of the floor area of the room. If the units are of semi or totally indirect type, measure the ceiling height of room and refer to table 2 for the permissible spacing of units and preferred suspension distance of lighting units

corresponding to this ceiling height.

If the units are of the direct lighting type, determine the mounting height and refer to table 3 for the permissible spacing corresponding to this mounting height. If the units are mounted as close to the ceiling as possible (a minimum allowance of one foot is usually necessary to provide for the drop of the reflector from the ceiling) a wider spacing is permissible and fewer units are, therefore, necessary for an even distribution of light. Considerations of shadows, appearance and arrangement of work may make a lesser mounting height desirable, even though a closer spacing of outlets would be needed to keep the same uniformity of illumination. Ordinarily, lamps should not be mounted less than 10 feet above the floor, unless a low ceiling makes it necessary.

Having determined the permissible spacing, proceed to locate the outlets on the diagram of the floor area. Locate the units as nearly symmetrically as possible, without appreciably exceeding the permissible spacing for uniform illumination. At a greater height, a spacing closer than that in tables 2 and 3 results in greater freedom from shadows, but increases the number of units required and makes the installation cost more. If a spacing somewhat closer than the permissible value is adopted, as is often the case, it is allowable, though not necessary, to refer back to tables 2 and 3 and select a lower mounting height, corresponding to the new spacing. The distance between the outside row of outlets and the wall should not exceed one-half the spacing distance. For office spaces, or where work is carried on at benches or

machines near the wall, this distance should be approximately one-third the spacing distance.

4. LAMP SIZE.

After the outlets have been located on the plan, the lamp size to be used must be determined by the following calculation:

(a) $\text{Area in Sq. Ft. per Outlet} = \frac{\text{Total Floor Area in Sq. Ft.}}{\text{Number of Outlets}}$

(b) $\text{Lamp Lumens required per Square Foot} = \frac{\text{Foot-Candles x Deprec'n Factor}}{\text{Coefficient of Utilization}}$

(c) $\text{Lamp Lumens required per Outlet} = \text{Area in Sq. Ft. per Outlet (from (a))} \times \text{Lamp Lumens required per Sq. Ft. (from (b))}$

Foot-Candles: Illumination decided upon.

Depreciation Factor: Safety factor, or allowance for depreciation, due to aging of lamps, dirt, dust and deterioration of reflecting value of walls. Use 1.3 for fairly clean locations. Use 1.5 for dirty locations or where cleaning is infrequent.

Coefficient of Utilization: Proportion of the generated light from the lamps, which reaches the plane of work. The determination of the coefficient of utilization depends upon color of walls and ceilings, etc.

Having determined the lamp lumens required per outlet by the above calculations, the wattage of Mazda lamps to be used may be found by reference to Tables which list the lumen output rating for each size of Mazda and Mazda Daylight lamps. Locate in this Table the size of lamp of the desired type which most nearly meets the requirement of lumen output. When the lamp lumens required fall nearly midway between two sizes, choose the larger rather than the smaller, unless it is certain that the less illumination from the smaller will suffice.

ILLUMINATION DESIGN FOR A FACTORY ROOM

The floor plan of the factory space to be lighted is 60' x 120' as shown.

The work carried on in the room is assembly of sewing machine heads.

Height from floor to roof trusses is 12 feet.

The roof is of sawtooth construction and the walls and upper structure are painted a medium color. A considerable amount of dark material is kept stacked along the walls of the room.

Following the steps outlined on pages 3 to 5 the lighting design is determined as follows:

1. FOOT-CANDLE ILLUMINATION

From Table 1, Page 39, 8 foot-candles are recommended for assembly, medium grade.

2. TYPE OF LIGHTING UNIT

Consulting the guide to the selection

of Reflecting Equipment of Table 1, Page 10, Unit No. 2, the RLM dome with bowl-enameled lamp is selected, based on efficiency and favorable showing from the standpoints of glare, reflected glare, shadows and maintenance.

3. LOCATION OF OUTLETS, MOUNTING HEIGHT, AND NUMBER OF UNITS

The height of the benches and therefore the plane of work is $3\frac{1}{2}$' above the floor. The maximum mounting height of the lamps above the floor is 11' (12' height from floor to truss less 1' allowed for reflector drop). Hence, maximum mounting height of units above plane of work is 11'—$3\frac{1}{2}$' or $7\frac{1}{2}$'

From Table 2-a of Spacing-Mounting Height, Page 12, a $7\frac{1}{2}$' mounting height above plane for direct lighting units is found to indicate a permissible spacing of

approximately 11' and since the section of the room near the walls consists of aisles ans storage, $5\frac{1}{2}$' may be allowed for the distance between the last row of outlets and the side walls.

Reference to floor plane of the room shows that a 10' spacing each way (outside units 5' from walls) would make a symmetrical layout in the 20' x 30' bays and this spacing is therefore adopted. Outlet locations for the entire space are marked on the plan as shown and 72 are found to be required.

4. LAMP SIZE

(a) Area in Sq. Ft. per Outlet $= \frac{\text{Total Floor Area in Sq.Ft.}}{\text{Number of Outlets in Room}} = \frac{7200}{72} = 100$

(b) Lamp Lumens Required Per Sq. Ft. $= \frac{\text{Foot-Candles x Deprec'n Factor}}{\text{Coefficient of Utilization}} = \frac{8 \times 1.30}{.57} = 18.2$

Area in square feet per outlet——100.

Foot-Candles——8.

Depreciation Factor——1.30.

Coefficient of Utilization——.57.

Combining (a) and (b)

(c) Lamp Lumens Required per Outlet = Area in Sq.Ft. per Outlet x Lamp Lumens Required per Square Foot = 100x18.2 = 1820.

Lumen Output of Mazda Lamps, a 150 watt Mazda "C" lamp giving 2040 lumens is found to most nearly meet the requirement. The actual service illumination using this lamp will, of course, be slightly greater than originally designed for, or

$$\frac{2040}{1820} \times 8 = 8.9 \text{ foot-candles}$$

TABLE No. 1

PRESENT STANDARDS OF ILLUMINATION---FOOT CANDLES

	Foot-Candles	
	Recommended	Under Some Conditions
Auditorium, Church	3	2- 4
Armory, Public Hall	5	3- 6
School--Class Room, Study Room, Library	8	5-10
Store		
Show Window	10-70	....
First Floor Department, Shop on Bright Street Corner	10	6-12
Other Clothing, Dry Goods, Haberdashery, Millinery, Jewelry, etc.	8	5-10
Other Drug, Grocery, Meat, Bakery, Book, Florist, Furniture, Lunch Room, Confectionery, etc.	6	4- 8
Office		
Private, General	10	6-12
Drafting Room	15	10-20
Industrial		
Aisles, Stairways, Passageways and Corridors	2	1- 2

TABLE No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Industrial (Cont'd)		
Assembling		
Rough	5	3- 6
Medium	8	5-10
Fine	10	6-12
Extra Fine	10-50	....
Bakeries	8	5-10
Boilers, Engine Rooms and Power Houses		
Boilers, Coal and Ash Handling, Storage Battery Rooms	3	2- 4
Auxiliary Equipment, Oil Switches and Transformers	5	3 -6
Switch Boards, Engines, Generators, Blowers, Compressors	6	4- 8
Candy Making	8	5-10
Canning and Preserving	8	5-10
Chemical Works		
Hand Furnaces, Boiling Tanks, Stationary Driers, Stationary or Gravity Crystallizing	3	2- 4
Mechanical Furnaces, Generators and Stills, Mechanical Driers, Evaporators, Filtration, Mechanical Crystalizing, Bleaching	4	3- 6

Table No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Chemical Works (Cont'd)		
Tanks for Cooking, Extractors, Percolators, Nitrators, Electrolytic Cells	6	4- 8
Clay Products and Cements		
Grinding, Filter Presses, Kiln Rooms,	3	2- 4
Molding, Pressing, Cleaning and Trimming	5	3- 6
Enameling	6	4- 8
Coloring and Glazing	10	6- 12
Cloth Products		
Light Goods	10	6-12
Dark Goods	15	10-20
Dairy Products	6	4- 8
Electric Manufacturing		
Storage Battery, Molding of Grids	6	4- 8
Coil and Armature Winding, Mica Working, Insulating processes	10	6- 12

Table No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Elevator, Freight and Passenger	5	3- 6
Forge Shops and Welding		
Rough Forging	6	4- 8
Fine Forging and Welding	10	6- 12
Foundries		
Charging Floor, Tumbling, Cleaning, Pouring and Shaking Out	5	3- 6
Rough Moulding and Core Making	6	4- 8
Fine Molding and Core Making	10	6-12
Glass Works		
Mix and Furnace Rooms, Casting and Lehr	5	3- 6
Grinding, Glass Blowing Machines, Cutting Glass to Size, Silvering	8	5-10
Fine Grinding, Polishing, Beveling, Inspecting, Etching and Decorating	10	6-12
Glass Cutting (cut Glass), Inspecting fine	10-50	....

Table No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Glove Manufacturing		
Light Goods		
Cutting, Pressing, Knitting	8	5-10
Sorting, Stitching, Trimming and Inspecting	10	6-12
Dark Goods		
Cutting, Pressing, Knitting	10	6-12
Sorting, Stitching, Trimming, and Inspecting	10-50	....
Hat Manufacturing		
Dyeing, Stiffening, Braiding, Cleaning and Refining		
Light	6	4- 8
Dark	10	6-12
Forming, Sizing, Pouncing, Flanging, Finishing, Ironing		
Light	8	5-10
Dark	10	6-12
Sewing		
Light	10	6-12
Dark	10-50	....
Ice Making		
Engine and Compressor Room	6	4- 8
Inspecting		
Rough	6	4- 8
Medium	10	6-12

Table No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Inspecting (Cont'd)		
Fine	15	10-20
Extra Fine	10-50	.....
Jewelry and Watch Manufacturing	10-50	.....
Laundries and Dry Cleaning	8	5-10
Leather Manufacturing		
Vats	3	2- 4
Cleaning, Tanning and Stretching	4	3- 6
Cutting, Fleshing and Stuffing	6	4- 8
Finishing and Scarfing	10	6-12
Leather Working		
Pressing and Winding		
Light	8	5-10
Dark	10	6-12
Grading and Matching, Cutting, Scarfing, Sewing		
Light	10	6-12
Dark	10-50	.....
Locker Rooms	4	2- 4

Table No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Machine Shops		
Rough Bench Work and Machine Work	6	4- 8
Medium Bench and Machine work, Ordinary Automatic Machines, Rough Grinding, Medium Buffing and Polishing	10	6-12
Fine Bench and Machine Work, Fine Automatic Machines, Medium Grinding, Fine Buffing and Polishing	12	8-16
Extra Fine Bench and Machine Work, Grinding (fine work)	10-50	....
Meat Packing		
Slaughtering	5	3- 6
Cleaning, Cutting, Cooking, Grinding, Canning, Packing	8	5-10
Milling and Grain Foods		
Cleaning, Grinding or Rolling	5	3- 6
Baking or Roasting	8	5-10
Packing		
Rough	4	3- 6
Medium	6	4- 8
Fine	10	6-12

Table No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Paint Manufacturing	6	4- 8
Paint Shops		
Dipping, Spraying, Firing	5	3- 6
Rubbing, Ordinary Hand Paiting, and Finishing	8	5-10
Fine Hand Painting and Finishing	10	6-12
Extra Fine Hand Painting and Finishing (Automobile Bodies, Piano Cases, etc.)	15	10-50
Paper Box Manufacturing		
Light	6	4- 8
Dark	8	5-10
Paper Manufacturing		
Beaters, Machine, Grinding	4	3- 6
Calendering	6	4- 8
Finishing, Cutting and Trimming	8	6-12
Plating	5	3- 6
Polishing and Burnishing	8	5-10

Table No. 1---Continued.

	Foot-Candles	
	Recommended	Under Some Conditions
Printing Industries		
Matrixing and Casting, Miscellaneous Machines, Presses	8	5-10
Proof Reading, Lithographing, Electrotyping	10	6-12
Linotype, Monotype, Typesetting, Imposing Stone, Engraving	10-50	....
Receving and Shipping	4	3- 6
Rubber Manufacturing and Products		
Calenders, Compounding Mills, Fabric Preparation, Stock Cutting, Tubing Machines, Solid Tire Operations, Mechanical Goods Building, Vulcanizing	8	5-10
Bead Binding, Pneumatic Tire Building, and Finishing, Inner Tube Operation, Mechanical Goods Trimming, Treading	10	6-12

TABLE 2 SPACING---MOUNTING HEIGHT

SEMI AND TOTALLY INDIRECT LIGHTING UNITS, No. 22 to No. 28

Ceiling Height			Permissible Distance Between Outlet and Sidewalls		
Above Plane of Work (H)	Above Floor (C)	Permissible Spacing Distance Between Outlets (D)	In Usual Locations Where Aisles & Storage are next to Wall (W)	In Offices or Where Work Benches are next to Wall (W)	Suspension Distance Ceiling to Top of Reflector (R)
5	7½	7½	3½	2½	1¼
6	8½	9	4½	3	1½
7	9½	10½	5	3½	1¾
8	10½	12	6	4	2
9	11½	13½	6½	4½	2¼
10	12½	15	7½	5	2½
11	13½	16½	8	5½	2¾
12	14½	18	9	6	3
13	15½	19½	9½	6½	3¼
14	16½	21	10½	7	3½
15	17½	22½	11	7½	3¾
16	18½	24	12	8	4
18	20½	27	13½	9	4½
21	23½	31½	15½	10½	5¼
24	26½	36	18	12	6
27	29½	40½	20	13½	6¾
30	32½	45	22½	15	7½
35	37½	52½	26	17½	8¾
40	42½	60	30	20	10

TABLE 3 SPACING---MOUNTING HEIGHT

Direct Lighting Units, Including Semi-enclosing and Totally Enclosing Units, No..1 to No. 21.

Mounting Height of Unit		Permissible Distance Between Outlets (D)	Permissible Distance Between Outlets and Sidewalls	
Above Plane of Work (H)	Above Floor (F)		In Usual Locations Where Aisles & Storage are Next to Wall (W)	In Offices or Where Work Benches are Next to Wall (W)
4	6½	6	3	2
5	7½	7½	3½	2½
6	8½	9	4½	3
7	9½	10½	5	3½
8	10½	12	6	4
9	11½	13½	6½	4½
10	12½	15	7½	5
11	13½	16½	8	5½
12	14½	18	9	6
13	15½	19½	9½	6½
14	16½	21	10½	7
15	17½	22½	11	7½
16	18½	24	12	8
18	20½	27	13½	9
20	22½	30	15	10
22	24½	33	16½	11
24	26½	36	18	12
27	29½	40½	20	13½
30	32½	45	22½	15
35	37½	52½	26	17½
40	42½	60	30	20

AUDITORIUMS.

Auditoriums, churches and ball rooms are often lighted by means of indirect fixtures with excellent results. Upon the other hand, direct methods are recognized as being quite capable of giving good service in many cases. Direct methods are apt to give a glare, which is to be guarded against. This feature may be corrected by using suitable glassware, which, of course, cuts down the efficiency very materially. Another means employed to give the same results is to sub-divide the source of light into numerous small units and distribute them well, still properly shaded. The use of a fixture with several lamps, rather than a one-lamp fixture, accomplishes this result in a limited way.

To go to the extreme of providing an enormous center chandelier is a reversal of results and bad glare occurs. When dependence is put on multiplicity of lamps, they should be well scattered and kept high. This sub-division introduces another desirable possibility.

In many cases it is better to arrange circuits so that a reduced number of lights may be used for a part of the evening. In churches this provides relief during the sermon. In lodge rooms, certain parts of the rituals need low intensity lighting. Theater lighting is less annoying, if it can be brought on in sections.

The center chandelier is not to be universally condemned for the auditorium.

Naturally, occupants of balconies are very apt to be disturbed and inconvenienced by it, but some ceilings are so high that it is quite possible to hang a central fixture well above the field of vision even of those in the back seats. The decorative features of this unit make its choice not at all infrequent. Few situations exist, however, where the mere illumination needs would not be very considerably better served by other methods.

The indirect lighting, of which mention has been made, is provided by central large unit fixtures, alone, or aided by cove lighting. Sometimes the latter is relied upon for the whole of the illumination. One of the first striking examples of indirect lighting from side sources

to be installed was that of the railroad station in Washington, D. C. The effect is good and at the same time rather striking. For narrow rooms, cove lighting is quite practical. It looks well with arched ceilings, provided the light is not thrown upon the ceiling in blotches. If large bowls are suspended in the center of the room, they may be provided with low power lamps between the semi-transparent bowl and the high efficiency reflectors concealed within. This keeps the bowl from appearing so dark against a well illuminated ceiling. The same purpose can be accomplished by finishing the outside of the bowl in white or old ivory. The general diffusion of light

then illuminates this bowl enough to cause it to appear well lighted.

High efficiency reflectors should be used for all this indirect service and provision must be made for cleaning the reflectors frequently. This statement includes the central fixture, which may be lowered by windlass.

An alternative, more or less partaking of each of the above methods, may be had by putting high candle-power lamps in a chamber above the diffusing glass ceiling of the room. This gives a low intensity source, as seen, provided the ceiling does not show spotted because of low-hung lamps or too concentrating reflectors. Sometimes the chamber itself is painted white and allowed to take much of the burden of diffusion.

The architecture of the room must be studied in the design of the lighting system and the choice of units. Ornate interiors must be furnished with similar fixtures, plain lines of architecture with similar fixture design.

Special effects are often required. For example, in lighting ritualistic churches, the symbolic uses to which lights are put play some part. The sanctuary, with its altar, needs special treatment, as do the choir stalls, reading desks, etc. A chancel arch offers a suitable frame for support and concealment of some lamps illuminating this part of the church.

A church was studied and a great many readings taken to determine the conditions. These tests showed that the

average intensity was a trifle less than 1½ foot-candles. This value is poor for a building of that type. There were no special fixtures for the organ and the intensity was less than ¾ of a foot-candle, with the additional disadvantage that the organist cast a shadow upon the music board. The church was erected fourteen years ago, and the lighting installation was made at that time. The walls and ceiling are of a light gray body, trimmed with white. This was of a flat finish and well kept. This surface gives a very good factor of utilization and provides a very good diffusing surface. The fixtures were of the globe type and mounted as shown in the blue print. The lamps were all

Mazda type "B", and several different sizes used in the wall brackets alone. The burnouts in ceiling fixtures were well taken care of. The design of an entirely new system would be a very difficult problem, because of the style of architecture, and the inaccessibility of the fixtures would make the maintenance difficult.

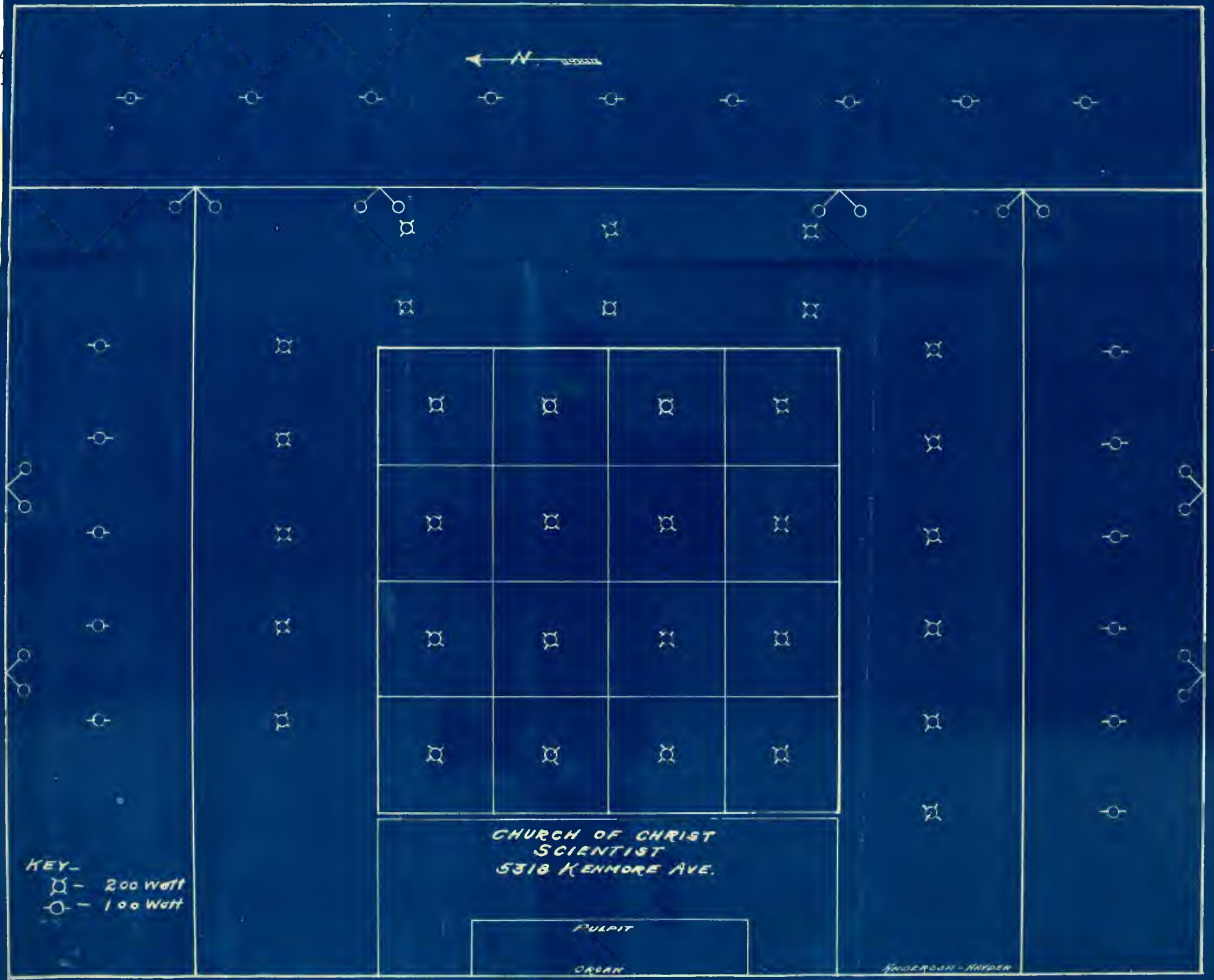
An installation of semi-indirect fixtures would be a satisfactory and efficient remedy. This type of unit, however, requires frequent cleaning in order to retain its efficiency. In order to maintain a system of this type properly, traps or openings would be required at each fixture, from which a workman could easily clean the glassware.

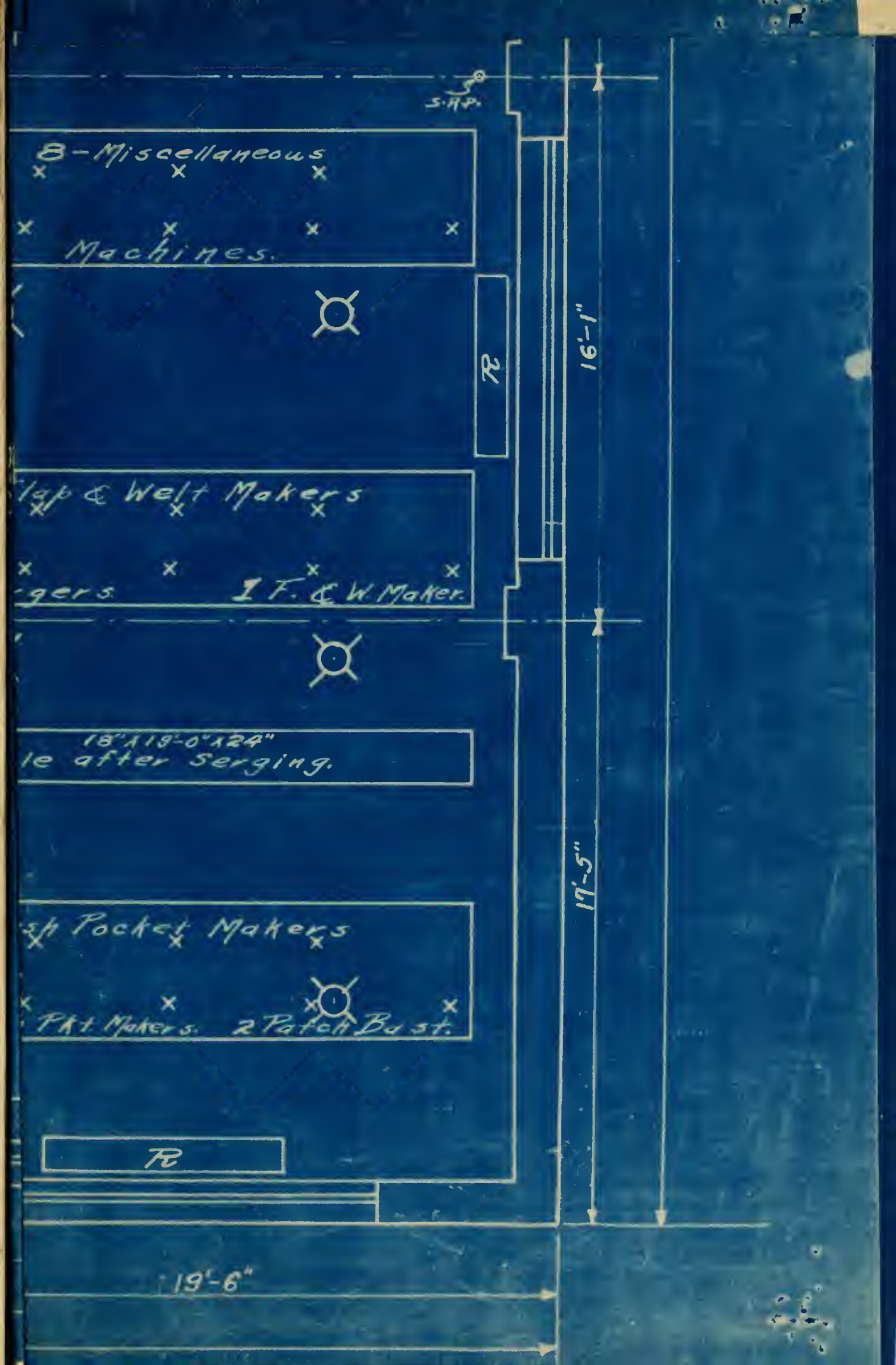
If conveniences of this sort could not be installed, large ladders would have to be used or scaffolding erected frequently. The installation of this complete system would prove expensive and churches are not usually prepared for expenses of this kind.

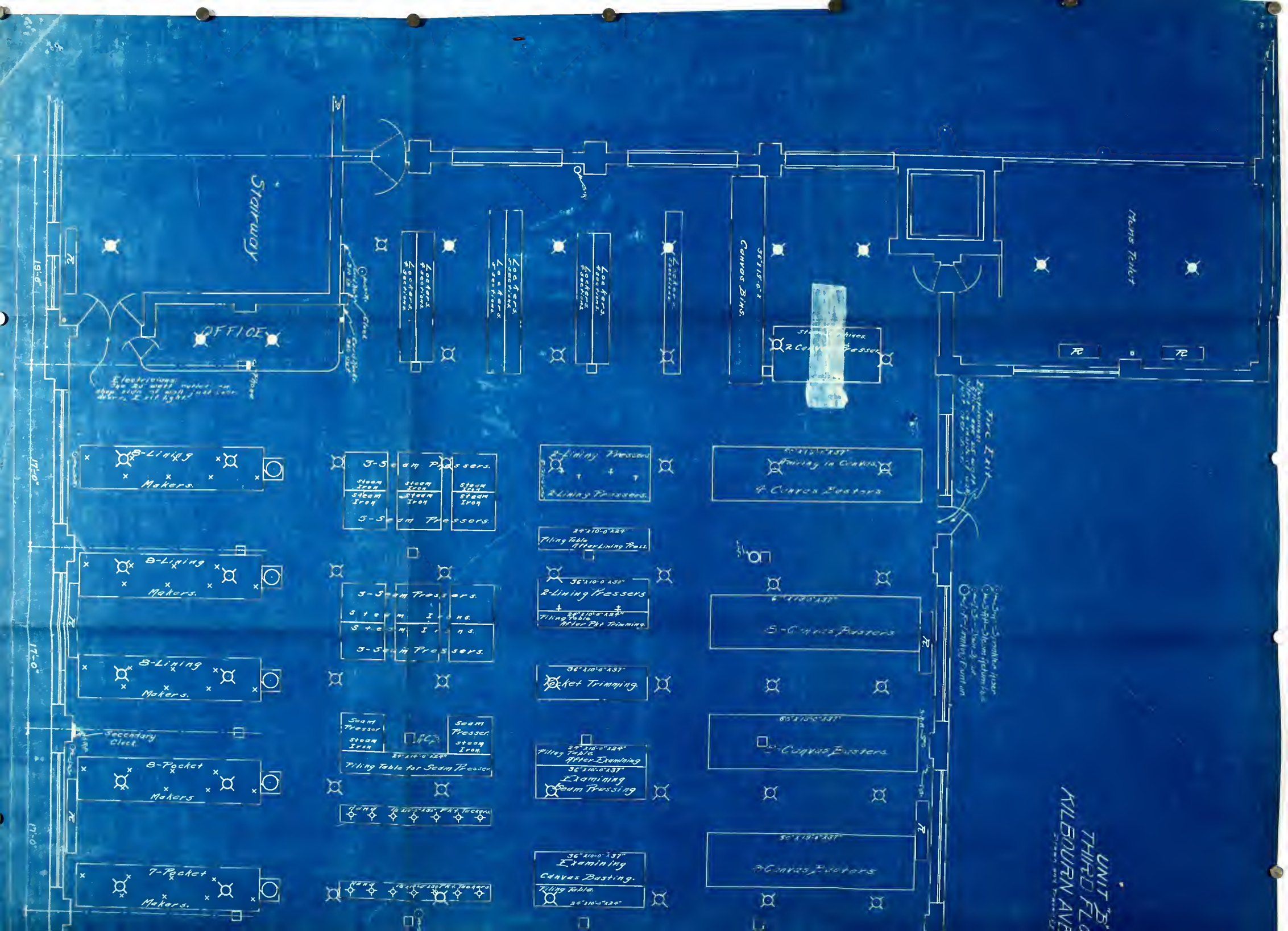
Inasmuch as this was the case at this church, an immediate and cheaper remedy was suggested. The lamps in the ceiling fixtures were to be changed from 100 watt "B" lamps to 200 watt "C" lamps and the wall fixtures fitted with 10 watt or 25 watt "C" lamps, because tests showed that they had very little effect upon the general illumination. It was also suggested that a small installation of cove lights should be made in the organ balcony. These

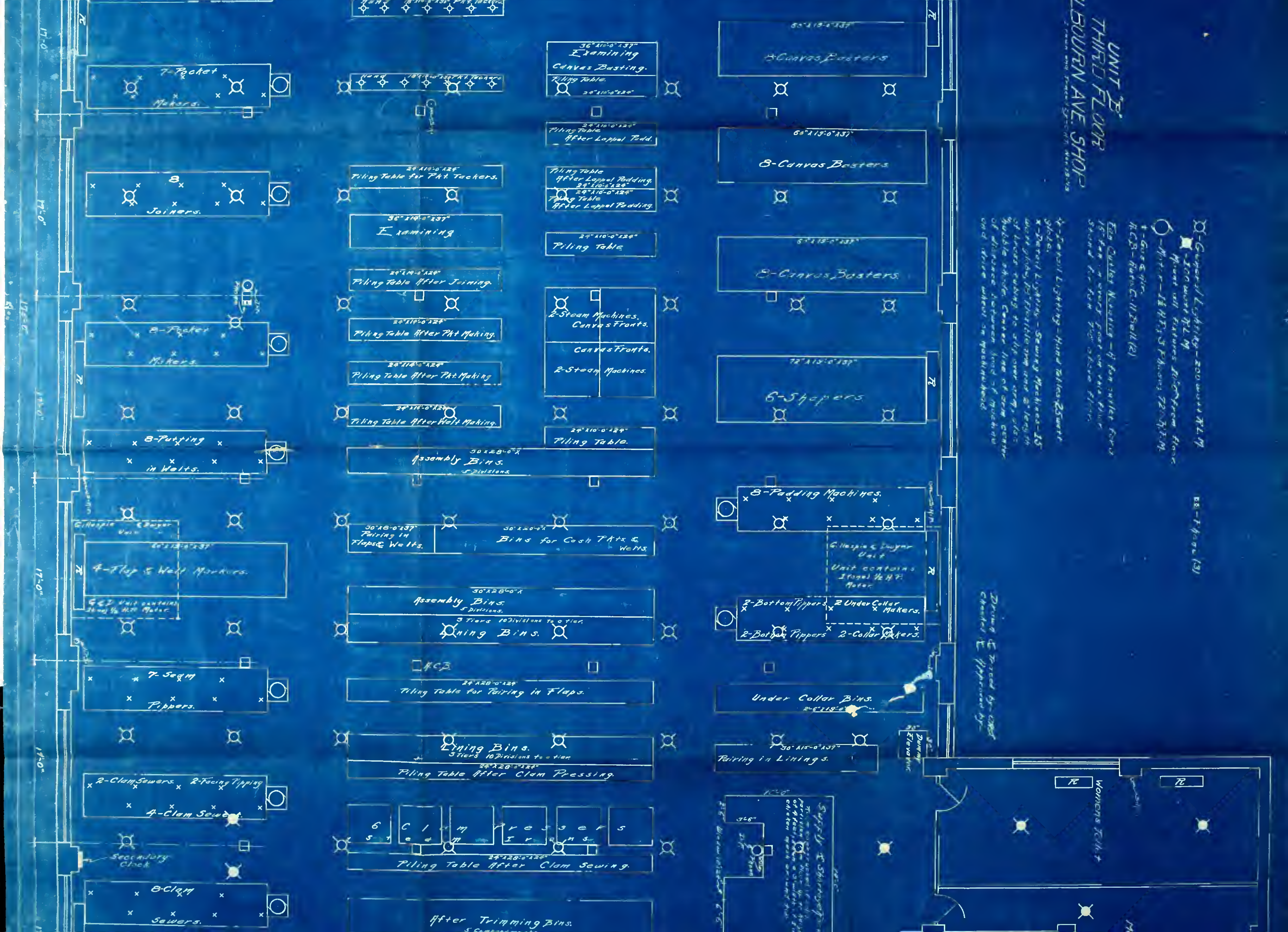
changes, when made, will bring the intensity up to about 5 foot-candles, but would, by no means, be ideal.

K

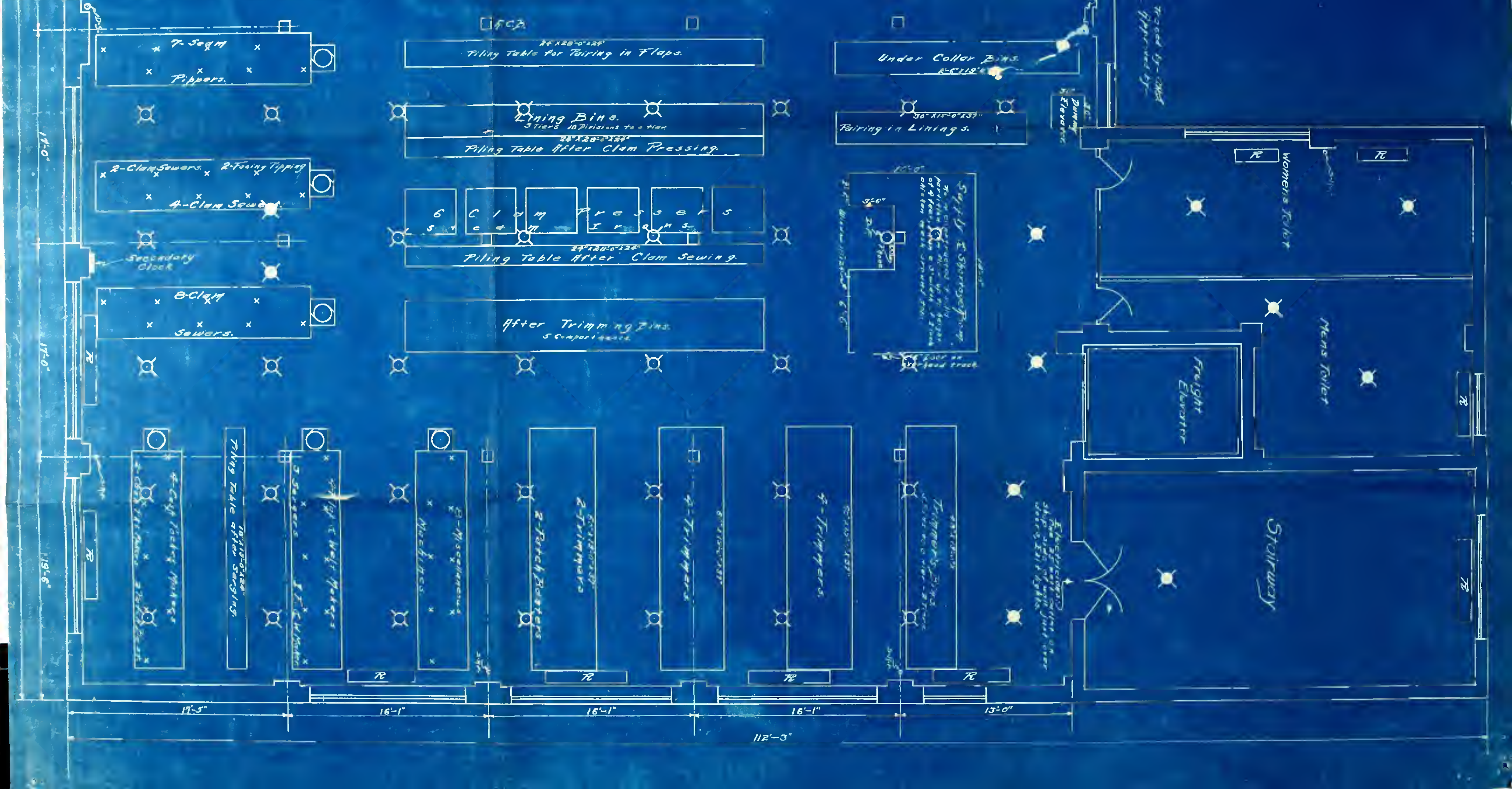

N
CHURCH OF CHRIST
SCIENTIST
5318 KENMORE AVE.
PULPIT
ORGAN
KEY-
200 WATT
100 WATT
ANDERSON-HAYDEN


5 H.P.
8 - Miscellaneous Machines.
R
16'-1"
Flap & Welt Makers
gers.
I F. & W. Maker.
18" x 19'-0" x 24"
le after Serging.
17'-5"
Pocket Makers
Pkt. Makers.
2 Patch Basst.
R
19'-6"


Stairway
OFFICE
Lockers 4 Sections
Lockers 4 Sections
Lockers 4 Sections
Lockers 4 Sections
Lockers
Canvas Bins
Mens Toilet
Fire Exit
Electricians
Secretary Clerk
8-Lining Makers.
8-Lining Makers.
8-Lining Makers.
8-Pocket Makers
7-Pocket Makers.
3-Steam Pressers.
Steam Iron
3-Steam Pressers.
3-Steam Pressers.
Steam Irons.
3-Steam Pressers.
Steam Presser Steam Iron
Steam Presser. Steam Iron.
Piling Table for Seam Presser
Lining Pressers
2-Lining Pressers
Piling Table After Lining Press.
36"x10'-0"x37"
2-Lining Pressers
Piling Table After Pkt Trimming
Pocket Trimming.
Piling Table After Examining
Examining Seam Pressing
Examining Canvas Basting.
Piling Table.
Pairing in Cranks
4 Canvas Pressers
5-Canvas Pressers
Canvas Pressers
PC Canvas Pressers
UNIT "B"
THIRD FLOOR
KILBURN AVE.



7-Pocket Makers.
8 Joiners.
8-Pocket Makers.
8-Putting in Welts.
4-Flap & Welt Makers.
7-Seam Pipers.
2-Clam Sewers. 2-Facing Tipping
4-Clam Sewers.
8-Clam Sewers.
Secondary Clock
Gillespie & Dwyer Unit
Piling Table for Pkt. Tackers.
Examining
Piling Table After Joining.
Piling Table After Pkt Making.
Piling Table After Pkt Making
Piling Table After Welt Making.
Assembly Bins. 5 Divisions.
Pairing in Flaps & Welts.
Bins for Cash Pkts. & Welts.
Assembly Bins. 5 Divisions.
Lining Bins.
Piling Table for Pairing in Flaps.
Lining Bins.
Piling Table After Clam Pressing.
6 Clam Pressers Irons
Piling Table After Clam Sewing.
After Trimming Bins.
Examining Canvas Basting. Piling Table.
Piling Table After Lappel Padd.
Piling Table After Lappel Padding.
Piling Table After Lappel Padding.
Piling Table
2-Steam Machines. Canvas Fronts.
Canvas Fronts. 2-Steam Machines.
Piling Table.
8-Canvas Basters
8-Canvas Basters
8-Canvas Basters.
6-Shapers
8-Padding Machines.
Gillespie & Dwyer Unit
2-Bottom Pipers. 2-Under Collar Makers.
2-Bottom Pipers 2-Collar Makers.
Under Collar Bins.
Pairing in Linings.
Dumb Elevator
Womens Toilet
UNIT E THIRD FLOOR
WELBOURN AVE. SHOP
Drawn & Traced by
Checked & Approved by



7-Seam Pippers.
Piling Table for Pairing in Flaps.
Under Collar Bins.
Lining Bins.
Piling Table After Clam Pressing.
Pairing in Linings.
2-Clam Sewers.
4-Clam Sewers.
6 Clam Pressers
Piling Table After Clam Sewing.
Secondary Clock
8-Clam Sewers.
After Trimming Bins.
Womens Toilet
Mens Toilet
Freight Elevator
Stairway
Piling Table after Serging
Machines.
2-Trimmers
4-Trimmers
4-Trimmers
17'-0"
17'-0"
19'-6"
17'-5"
16'-1"
16'-1"
16'-1"
13'-0"
112'-3"